Presentation to TEXAS II

Technical eXchange on AIS via Satellite II

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SpaceQuest, Ltd.

www.spacequest.com

AO-27

- Founded 1994
- Based in Fairfax, Virginia
- Focused on microsatellite technologies. (37 spacecrafts to date)
- Built and launched Microsats for LatinSat, Aprize and AMSAT.
- Provides Microsat subsystems to NASA, Canadian Space Agency, US Air Force, US Navy, US Aerospace Corporations, Universities, and
  Foreign Space Agencies.
- Developed all avionics systems & software for Bigelow Aerospace.
- Conducted [illegible] flight qualification programs

LatinSat

AprizeSat

Bigelow Genesis II

Technical Approach to AIS Investigation

Objective

- Investigate the nature and characteristics of the AIS signals as seen in space.

Satellite Equipment

- Use a sensitive 2-channel VHF receiver, tap the IF, filter, down-convert to 57 KHz, and modulate the carrier of an S-Band transmitter.

Ground Equipment

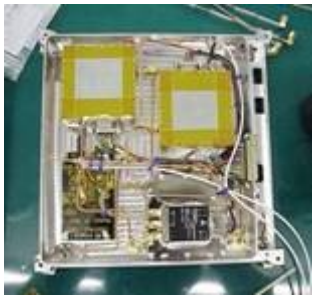
- Use a wideband S-Band receiver on the ground, oversample with 16-bits at 111 kbps, and record the digital data.
- Reconstruct the original analog signal on the ground and decode the AIS packets using a standard AIS receiver.
- Process the digital samples to investigate various decoder algorithms to maximize the retrieval of AIS information.

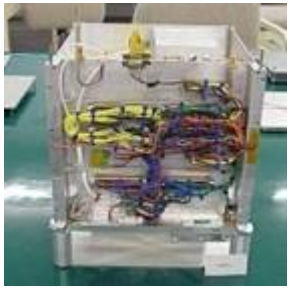
SpaceQuest Microsatellite Bus

Mission:

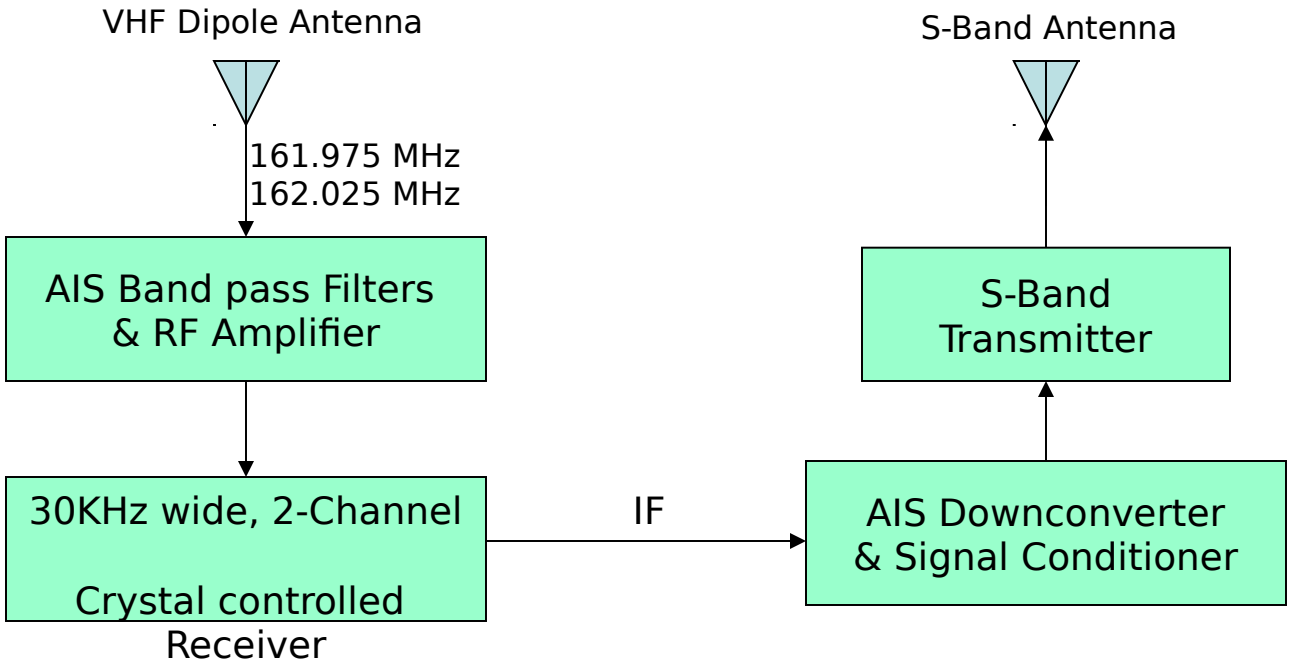
Data Exfiltration with auxiliary AIS payload.

- 12 kg, 25 cm cubes
- 10+ years orbital lifetime
- Low-cost, high performance
- Inexpensive piggyback launch
- Autonomous operation
- Global Store and Forward Operation
- Communicates via data links with thousands of terminals worldwide



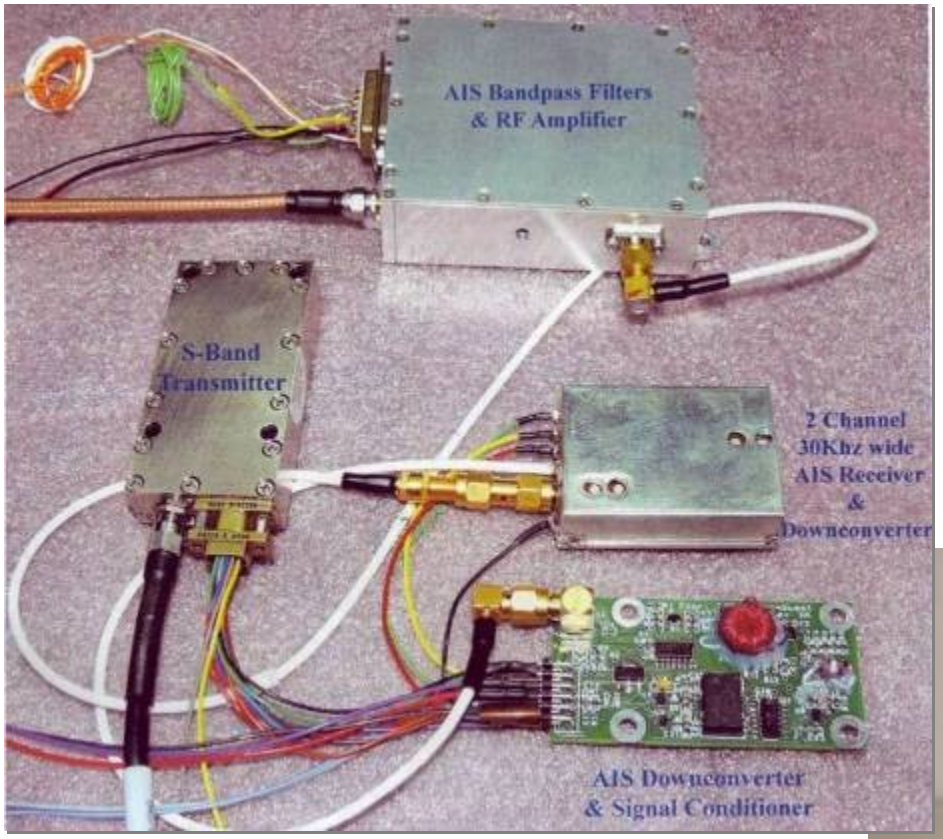


SpaceQuest AIS Payload Block Diagram



- 162 MHz receiver captures AIS signals
- Receiver IF used to modulate S-Band transmitter
- AIS signal contains corrupted packets, collisions, interference signals, and distorted signal transmissions.

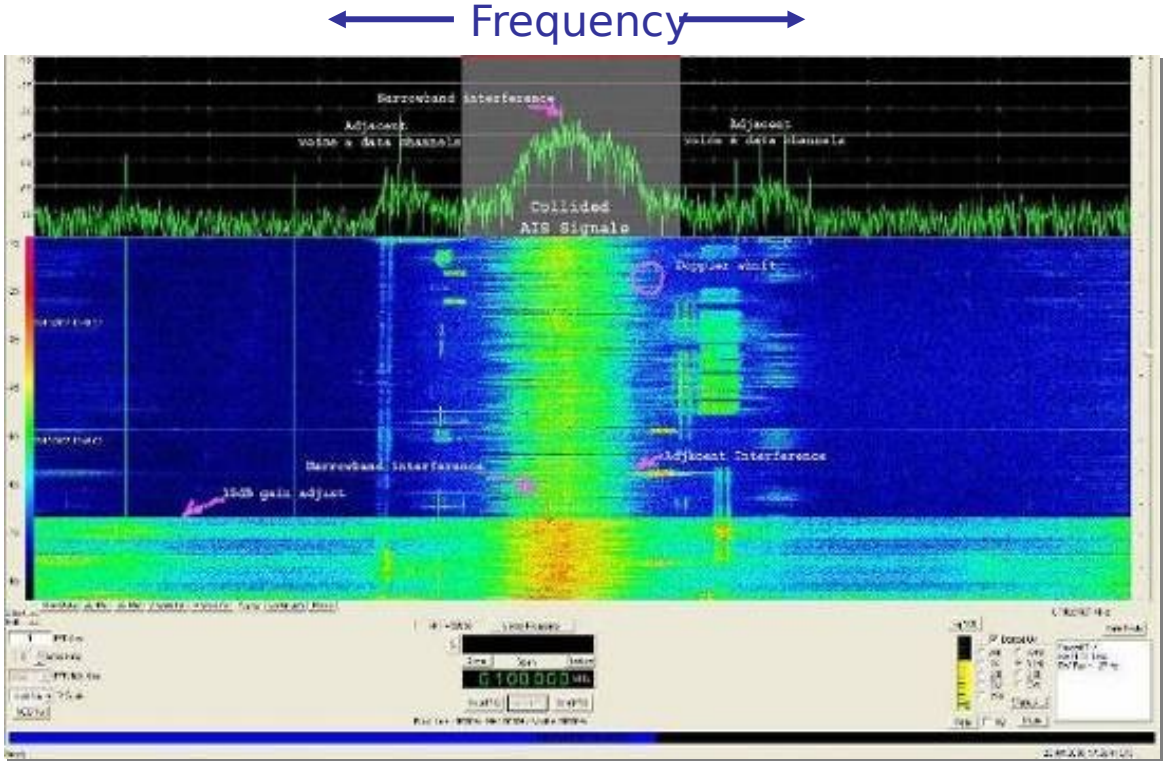
SpaceQuest's AIS Equipment



Satellite AIS Payload

S-Band Receiver & Digital Recorder

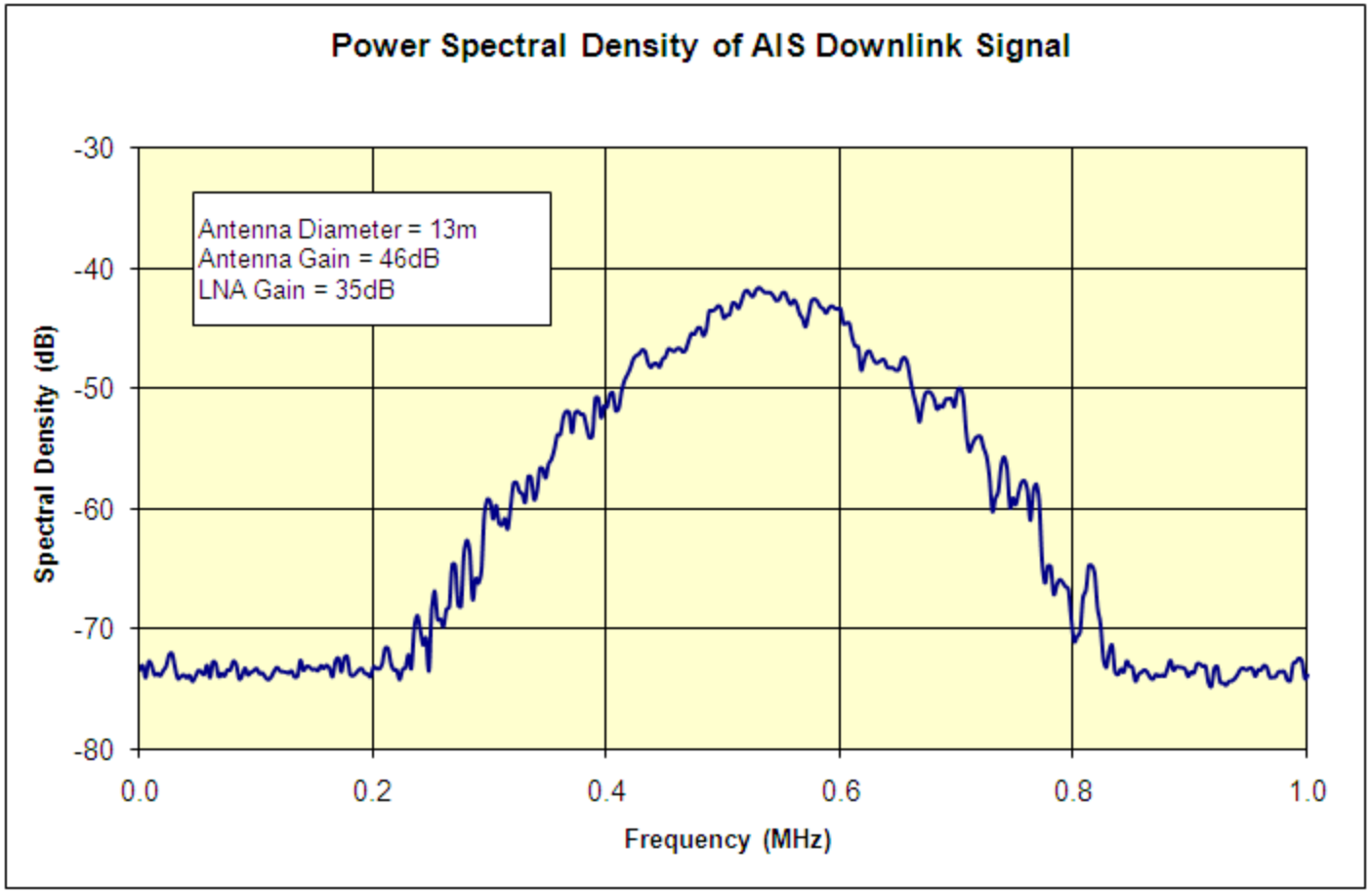
AIS Data Collection from Blossom Point



Real-Time AIS Spectrum

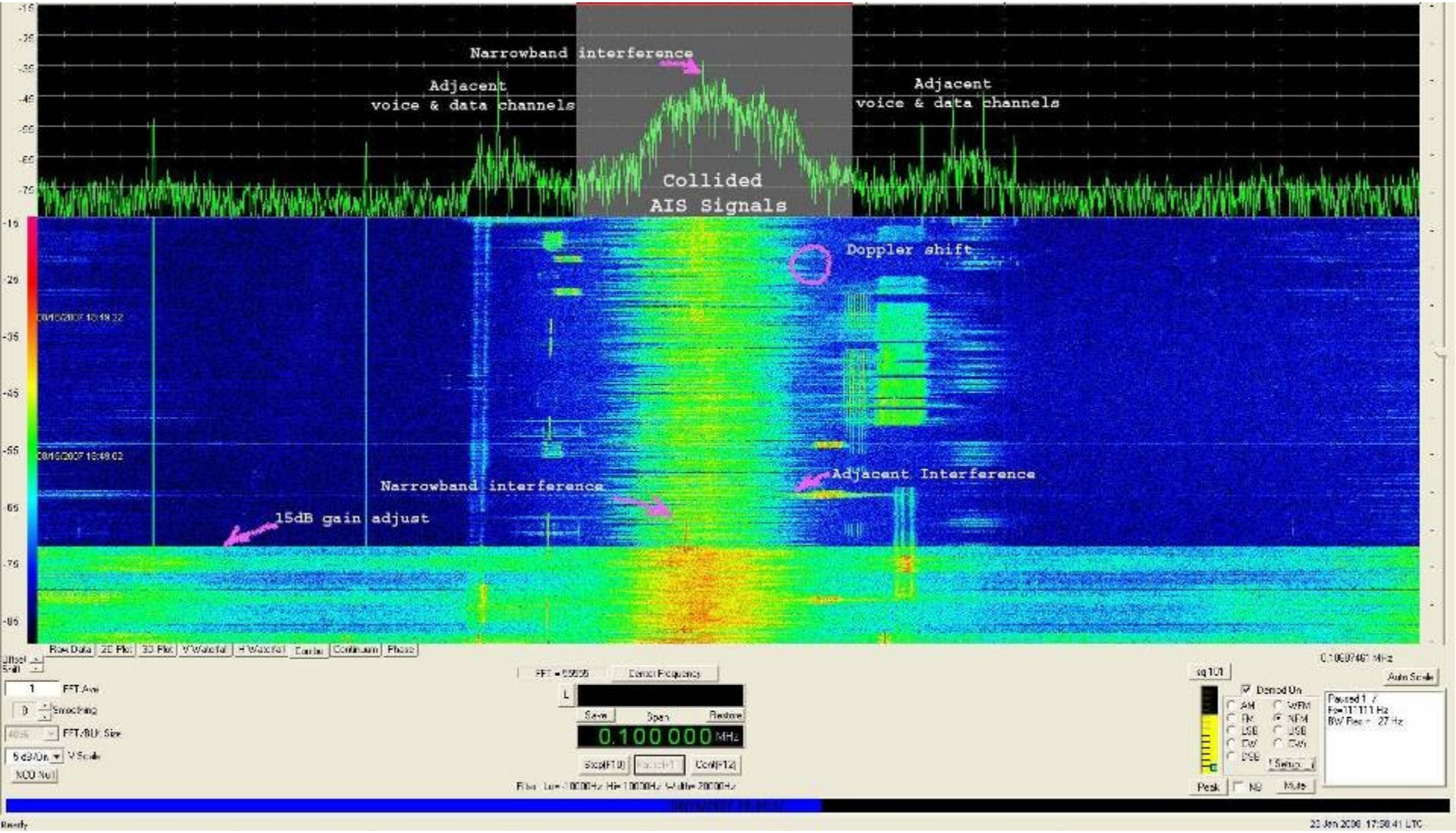
13-meter S-Band Antenna

Power Spectral Density of S-Band Downlink

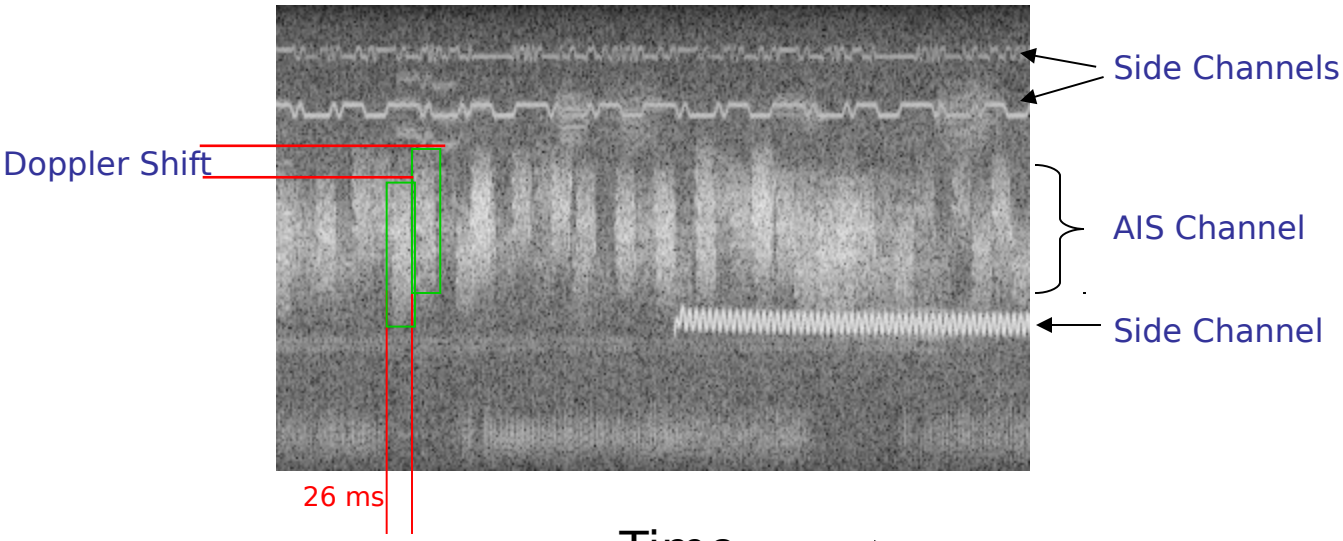


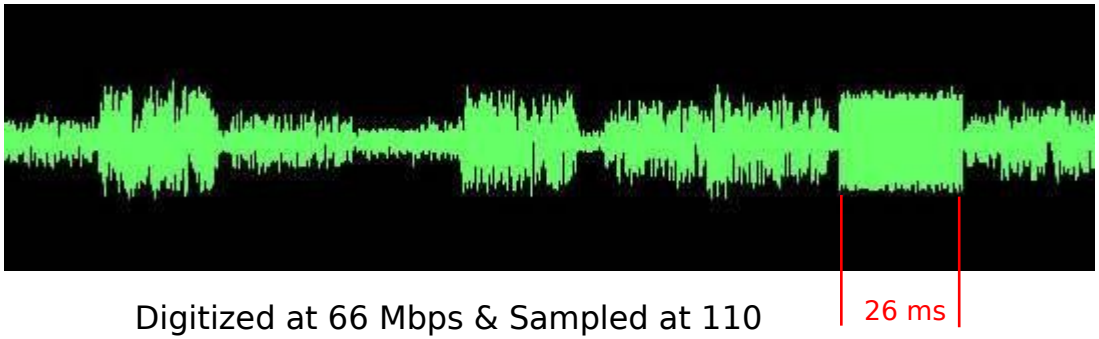
S-Band Antenna at Blossom Point

Spectral Plot of Wideband Analog Signal in AIS Band



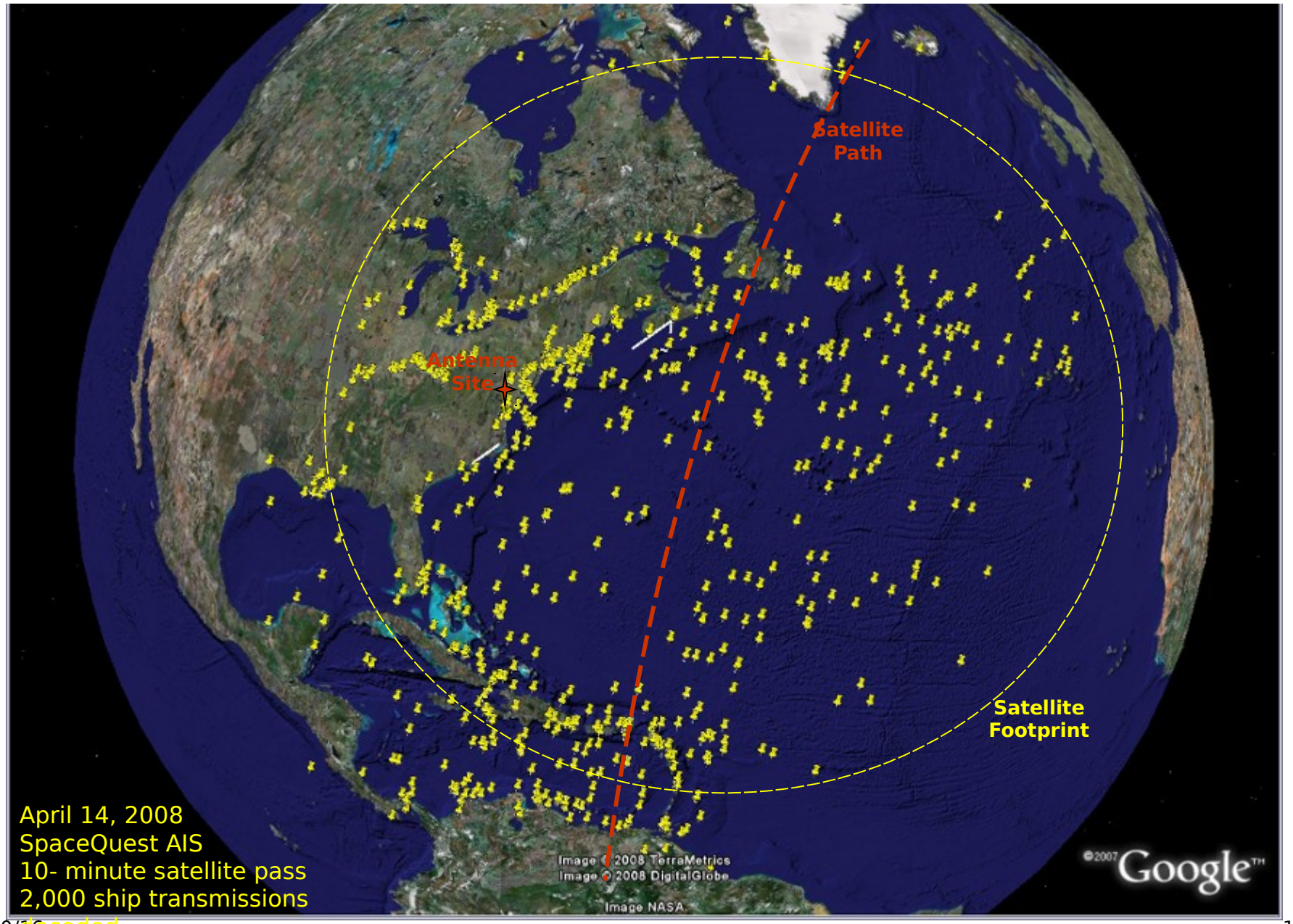
Analysis of Digitized AIS Signals from Space



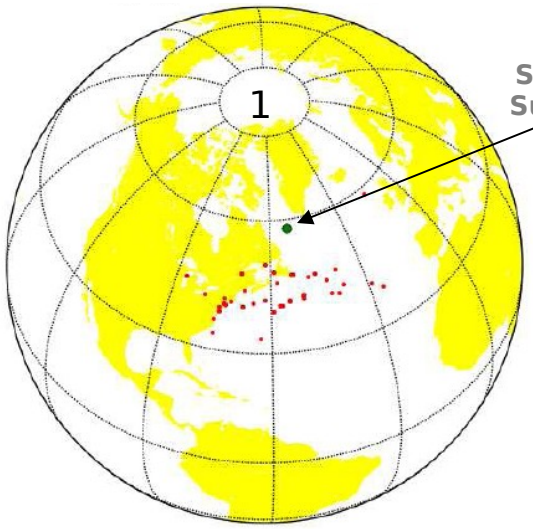


Digitized at 66 Mbps & Sampled at 110 kHz

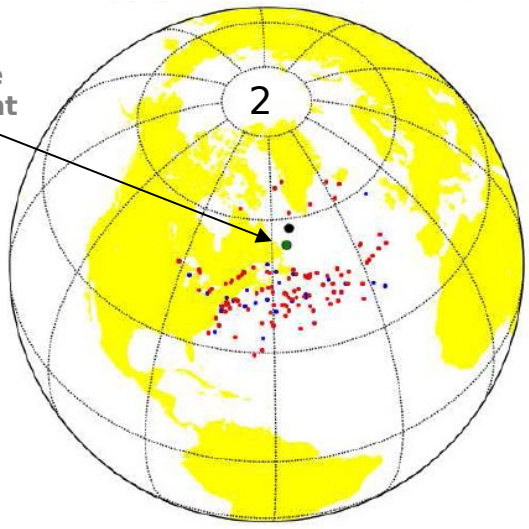
Decoded AIS Signals from a Satellite Pass over Atlanti



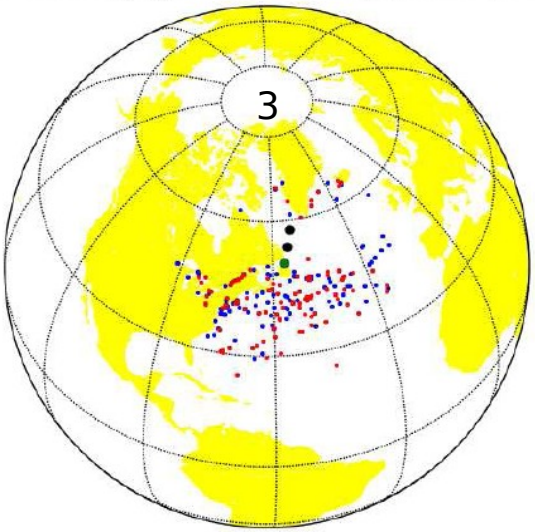
New Ships Received Each Minute



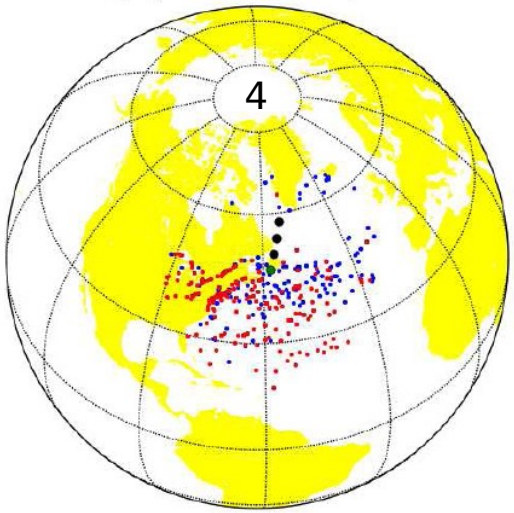
Minute #1: 43 New Ships



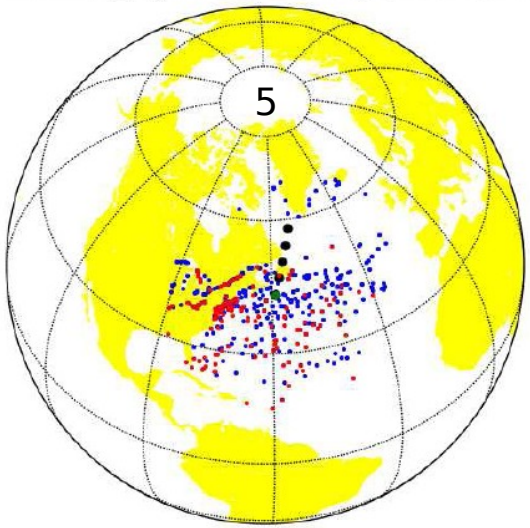
Minute #2: 139 New Ships



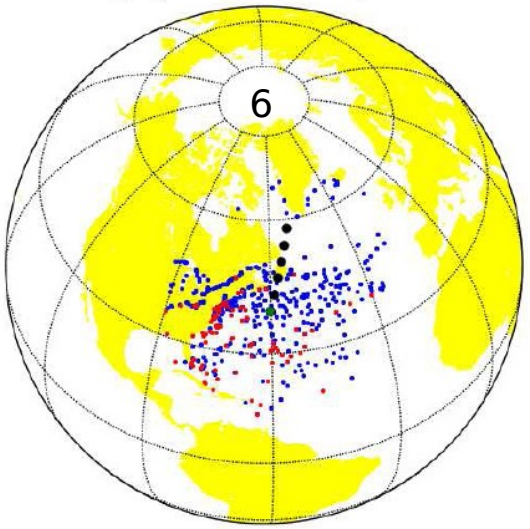
Minute #3: 133 New Ships



Minute #4: 303 New Ships



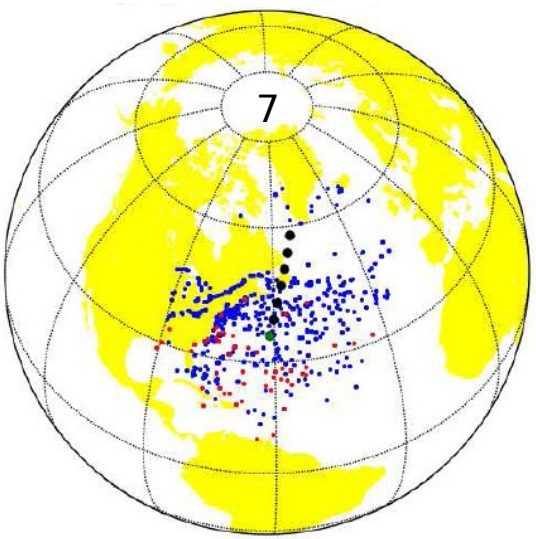
Minute #5: 240 New Ships



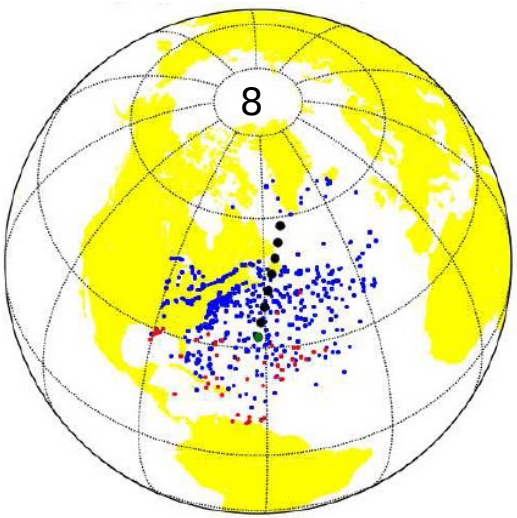
Minute #6: 131 New Ships

Courtesy of NRL

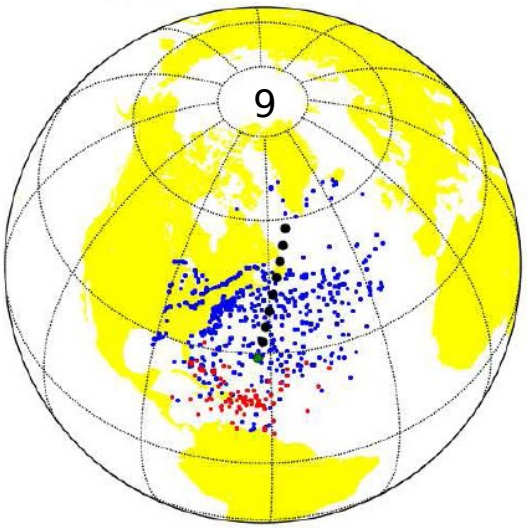
New Ships Received Each Minute



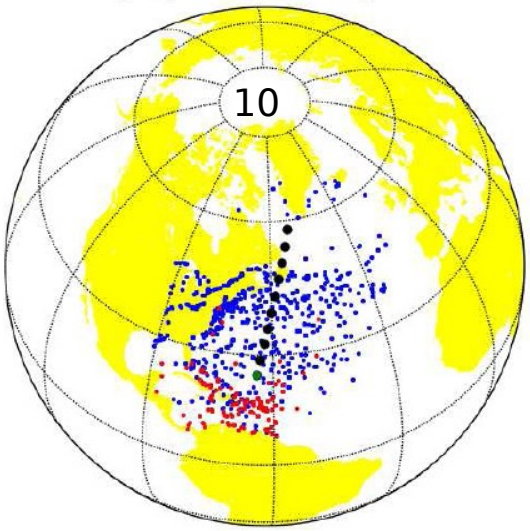
Minute #7: 57 New Ships



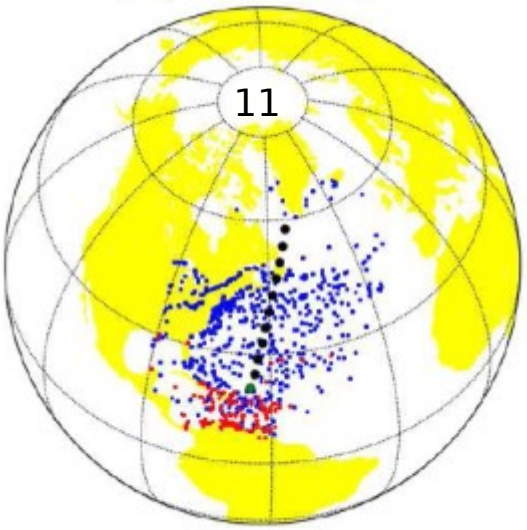
Minute #8: 55 New Ships



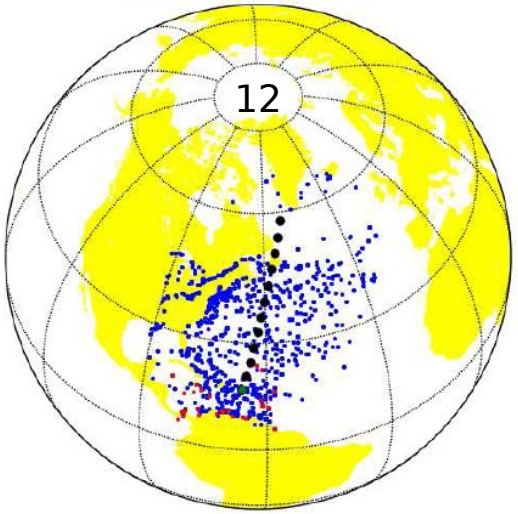
Minute #9: 118 New Ships



Minute #10: 164 New Ships



Minute #11: 168 New Ships

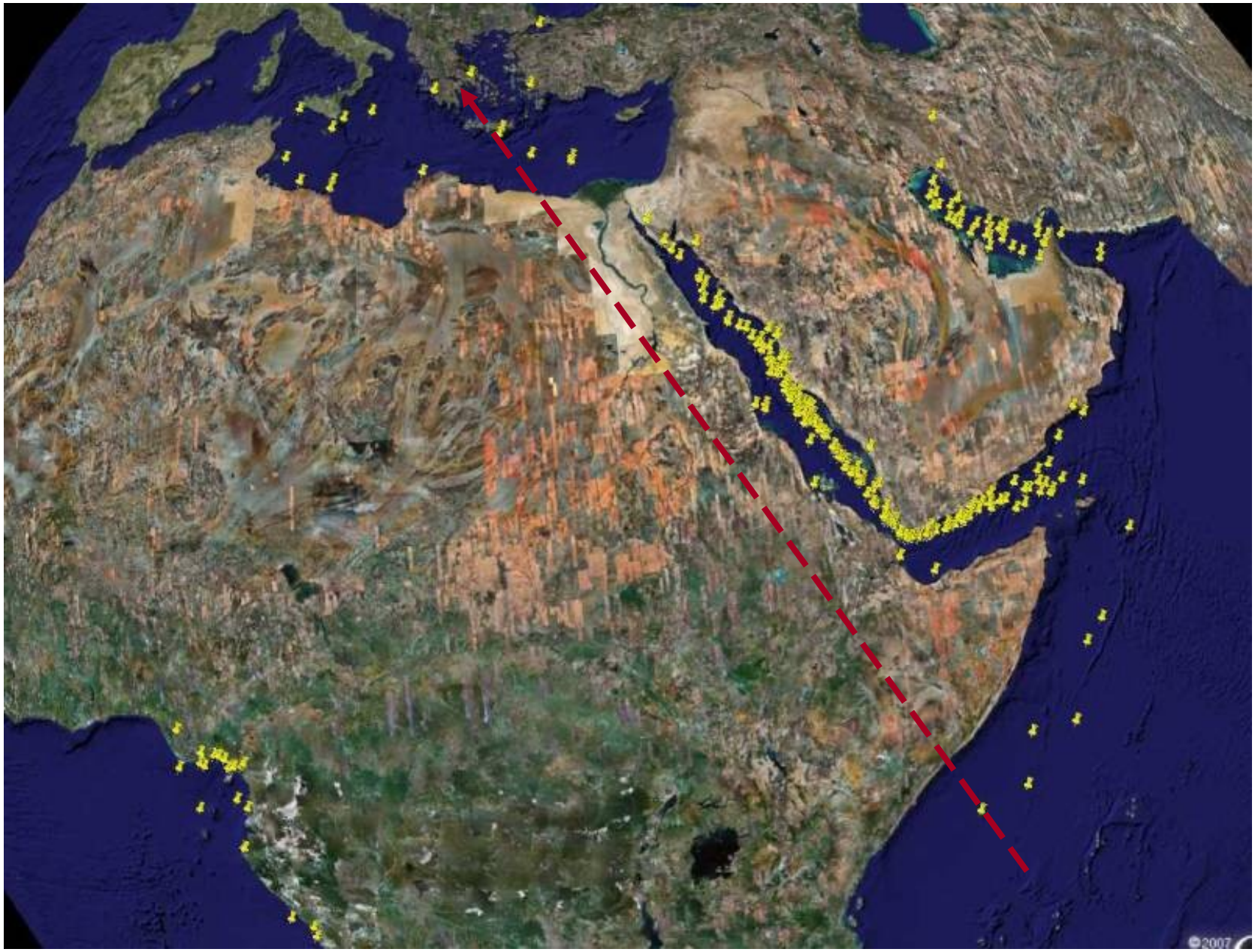


Minute #12: 29 New Ships

Courtesy of NRL

Test Setup in Riyadh, Saudi Arabia

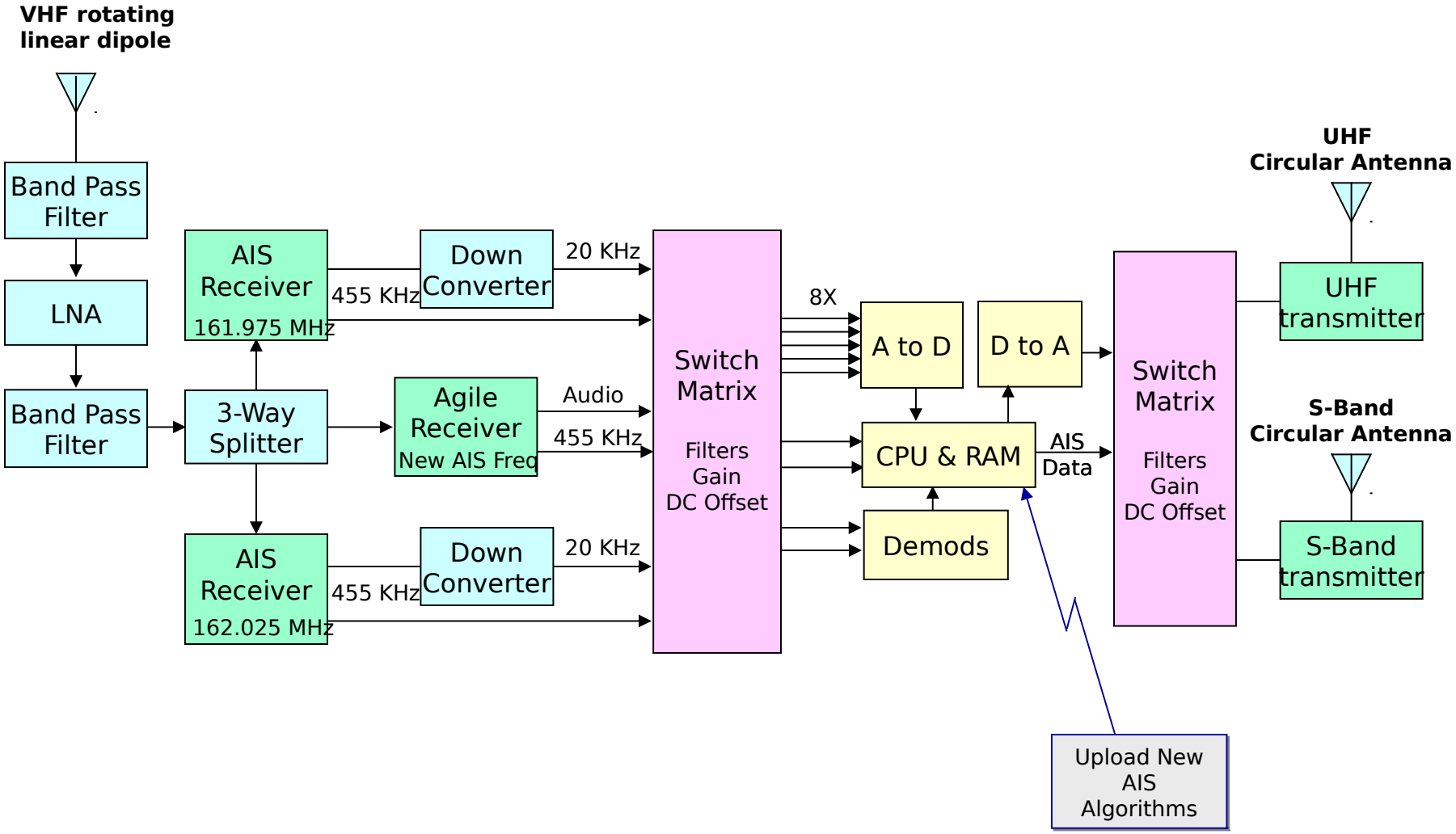
AIS Results from Saudi Arabia Antenna



Observations

- SpaceQuest's experimental AIS payload provided high-fidelity AIS signals from space.
- Land-based interference appears to be more dominant than sea-based interference, especially south of the US and over Europe
- The data sampling rate and resolution can be substantially reduced to create smaller data files.
- The satellite transponder bandwidth can be reduced to 20 kHz to improve system performance, reduce the size of the recorded file, and allow the use of a UHF downlink.
- On-board sampling, storage, and data processing will permit worldwide collection of AIS data on a routine basis.

Block Diagram of Advanced AIS Payload



Some Accomplishments

- Received and recorded high-fidelity AIS signals from space in real time.
- Modified and assembled low-cost, portable, off-the-shelf ground station equipment to receive, digitize and store AIS signals from space.
- Observed the emissions and interference in both AIS channels as well as the adjacent channels from space.
- Recorded AIS emissions from open ocean and inland waterways during daytime and evening hours, and from the US west coast, east coast and the Middle East.
- Determined the aggregate energy level of the AIS signals in space into an omni-directional antenna.
- Validated and adjusted a space-based AIS payload.
- Decoded up to 2,000 ship transmissions during a 10-minute satellite pass.